Circular No. 681

September 1943 • Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

Spring Dwarf and Summer Dwarf of Strawberries[1]

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CONTENTS

Two different diseases of strawberry plants in the United States are usually called dwarf or crimp. In many respects the two are similar; each is characterized by stunting and abnormal growth of the plant caused by a parasitic nematode or eelworm that lives within the bud, and each is controlled by substantially the same practices. Despite many similarities, there are certain important and clear-cut differences between them, and it should be kept in mind that the two diseases are caused by different nematode species. The two can be conveniently and appropriately distinguished by calling them spring dwarf and summer dwarf, respectively.

Spring dwarf is probably identical with a disease of strawberries that is known in England as red plant. It was first observed in the United States near Falmouth, Mass., during the spring of 1932, and there is reason for believing that it had not existed in this region for many years prior to this date. It probably has been present on the Chesapeake Peninsula for at least an equal length of time, though its presence there was not recognized until 1938.

Summer dwarf is by no means new to the United States. It was established in Florida, Louisiana, and the Carolinas at least 20 years ago and probably has been present in Florida for 50 years. In previous publications this disease has usually been referred to as either dwarf or crimp; other names used by growers in Florida and Louisiana include crimps, French bud, white bud, brier bud, possum ears, frenching, curly leaf, male plant, and wild plant.

[1] This circular supersedes Circular 297, Strawberry Dwarf, by J. R. Christie and Neil E. Stevens, issued in 1933.

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When spring dwarf was first discovered on Cape Cod it was believed to be the dwarf disease of the South, recently introduced and behaving in a somewhat different manner under different climatic conditions. The first published reports of the Cape Cod situation dealt with the disease from this point of view, but subsequent investigations have demonstrated that two different diseases are involved.

CAUSES OF THE TWO DISEASES

Spring Dwarf

Spring dwarf is caused by a nematode or eelworm (*Aphelenchoides fragariae* (Ritzema Bos, 1891)) that lives in the bud of the plant between the partly formed leaves. This nematode is about one thirty-second inch long, or slightly less than 1 millimeter; it is very slender and is not visible to the naked eye. Its mouth is provided with a small hollow stylet, or spear, with which it punctures the tender plant cells and sucks out their content. The injury inflicted by one nematode is very slight and would have no noticeable effect on the plant, but as many as 8,000 to 12,000 nematodes may occur in a single bud. As a result, the cells over nearly the entire outer surface of a young, partly formed leaf may be destroyed, making the leaf small and distorted when it unfolds. The parasites are not found within the tissues of mature foliage, and all abnormalities are due to injuries sustained while the leaves were in the formative stage. The nematodes are found in the bud or between the bases of petioles throughout the year, but are most numerous in spring.

Summer Dwarf

Summer dwarf, which is caused by a bud-inhabiting nematode (*Aphelenchoides besseyi* Christie, 1942) that is very similar to, though not identical with, the one that causes spring dwarf, injures the plant in the same manner. The nematode is found in the bud throughout the year, but is most numerous in midsummer, when the number may approach, though rarely exceed, 1,000 per bud.

SEASONAL BEHAVIOR OF DISEASED PLANTS

Spring Dwarf

Spring dwarf is a cool-weather disease. Recognizable symptoms appear in spring soon after the plants start growth, the precise time depending on season and locality. The writer has observed unmistakable symptoms on experimental plants growing at Willard, N. C., as early as March 16, and probably they could have been recognized earlier. In the region of Falmouth, Mass., symptoms usually become evident about the middle of April. The symptoms are most severe from the time they appear in spring until the advent of hot summer weather. As summer advances the plants develop more nearly normal foliage, thus gradually masking the earlier spring symptoms. If a plant is lightly infected and the spring symptoms were slight or moderate, the summer foliage may show little if any recognizable abnormality. Where spring symptoms were severe it is doubtful

whether the summer foliage will at any time be devoid of some crinkling and abnormal appearance, though this may not be conspicuous and may become less so as the season advances. In some cases plants remain noticeably stunted. On Cape Cod there is a tendency for the nematode population to build up in fall, resulting in slight fall symptoms.[2]

Summer Dwarf

Summer dwarf is a hot-weather disease. In Florida, one of the earliest observations regarding summer dwarf was that it appeared to be less severe in cold weather. Throughout its known range the period of most conspicuous symptoms is from about July 1 until about October 1. In Florida, however, usually some diseased plants can be recognized at any time of the year when temperatures are not too low and the plants are growing.

In North Carolina and in Maryland, summer dwarf can be recognized only during the summer months. Spring foliage does not appear to have any of the characteristic symptoms, but these always return with the approach of warmer weather. During the fruiting season infected plants are not distinguishable from the uninfected, though in Maryland the disease may sometimes be recognized as early as June 10. Beginning some time during September, plants have a tendency to grow out of the disease and the symptoms gradually become less pronounced.

SYMPTOMS

Spring Dwarf

In early spring diseased plants are recognized by the abnormal appearance of the crown. The bud is small and poorly developed or may even be dead. There is a noticeable reduction in the number of hairs in and around the growing point. The surrounding stipules are frequently more reddish or brownish than normal and may be partly killed. Development of the foliage is retarded. On Cape Cod, and probably elsewhere, severely affected plants may fail to develop foliage and may eventually die, or they may develop small distorted foliage abnormally late in the season. As the leaves of a heavily infected plant begin to unfold and elongate they are especially abnormal in appearance, the petioles being swollen and the leaflets narrow and thickened. When these leaves are fully formed they are small, the petioles are short, and the leaflets are narrow, often thickened, and show varying degrees of crinkling and distortion (fig. 1). When the crown is cut open the fruit bud is found to be dead. When the infection is light the leaves may be of normal size and shape, the only manifestation of the disease being a crinkling of the leaves and, in some cases at least, a slightly to a much darker color. Early and midsummer symptoms are typically of this character. Lightly infected plants begin developing runners earlier than uninfected ones. Though the number of runners on heavily infected plants is reduced and the internodes are shortened, on lightly infected plants the number of runners may even be increased.

[2] Oral communication from Bertram Tomlinson, county agricultural agent, Barnstable County, Mass.

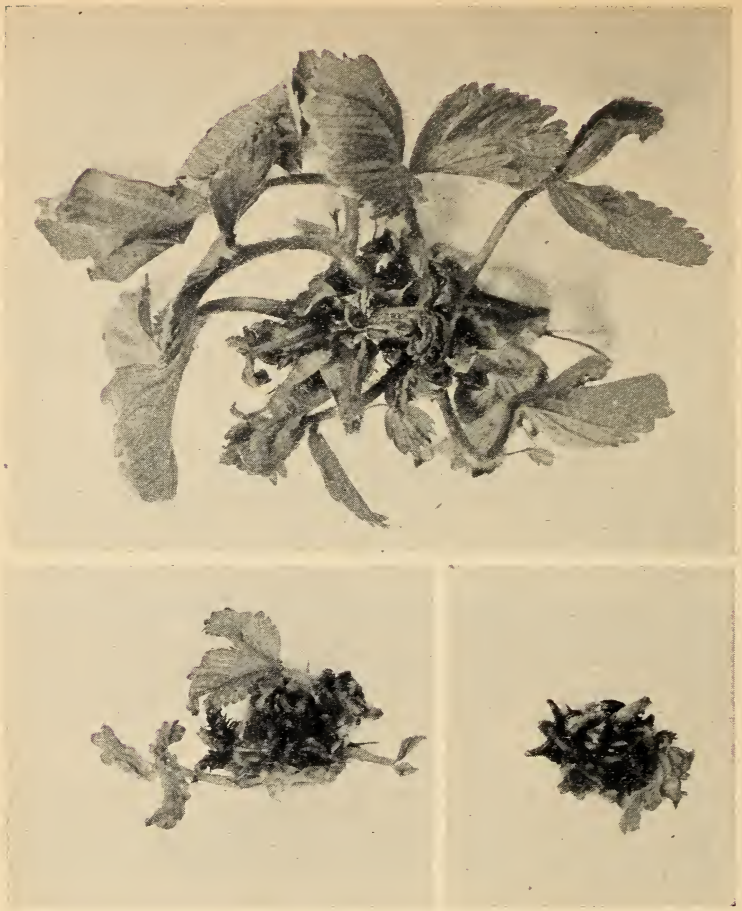

FIGURE 1.—Strawberry plants, variety Howard 17 (Premier), from Falmouth, Mass., showing symptoms of spring dwarf.

When the central bud is killed or its growth is retarded there is a tendency for adventitious buds at the base of the crown to be forced into growth, making "multiple-crowned" plants. While the multiple-crown type is occasionally found in connection with spring dwarf, it is probably more characteristic of certain other strawberry troubles.

Leaf spots or lesions are not a characteristic symptom and when present are usually due to some cause other than nematode injury.

In continental Europe and in England strawberry plants are subject to a malady resulting in such extreme fasciation that the trouble is called cauliflower disease. The claim has been made that red plant and cauliflower disease are merely different responses of the plant to the same bud nematode. Recent evidence indicates that the English fasciation is due to a bacterium. The writer has seen no evidence to indicate that fasciation in this country is a characteristic symptom of spring dwarf.

Summer Dwarf

The symptoms of summer dwarf (fig. 2) are almost identical with those of spring dwarf, such differences as can be detected being due largely if not entirely to seasonal differences in the growing habits of the plants. In summer dwarf, as compared with spring dwarf, the petioles and leaflets of developing foliage tend to be somewhat less swollen and succulent and the plant usually has an outer circle of older and more or less normal foliage developed earlier in the season.

HOW THE DISEASES SPREAD

The manner of spread is the same for both spring dwarf and summer dwarf. The use of infected planting stock is by all odds the most important means of dissemination. This is the only way that either

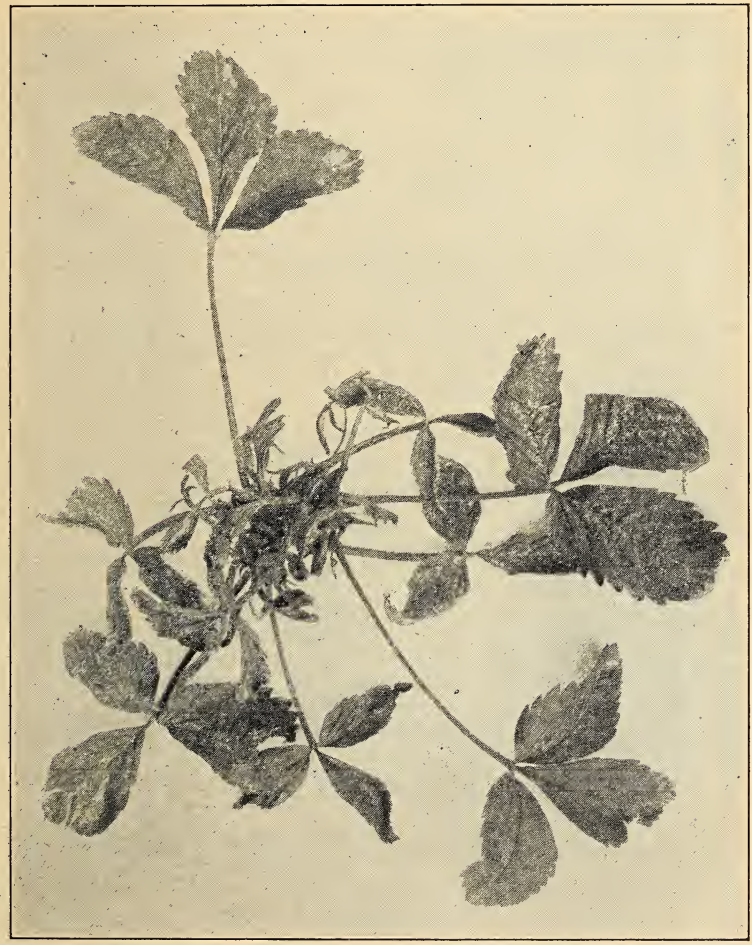

Figure 2.—Strawberry plant, variety Klondike, from Chadbourn, N. C., showing symptoms of summer dwarf.

disease can be introduced into a new region and the only way it is likely to spread from field to field.

Spread in the field may take place in various ways. Most of the runner plants produced by a diseased mother plant are likely to develop symptoms sooner or later. This is because the parasites are carried out in the bud that terminates the runner. When plants are wet the nematodes may leave their position in the bud and move over the surface of the foliage in a film of water. Where leaves touch each other the parasites may migrate directly from plant to plant. During heavy rains they may be washed off and out of the plants and be disseminated over the lower parts of the field.

DISTRIBUTION

In reporting the present known distribution of either of these diseases a distinction should be made between instances where the disease is more or less widespread and apparently permanently established in a region and instances where it has merely been found in an individual field. Usually a case of the latter type has been the result of setting infected plants that were not of local origin, and it does not necessarily indicate that the disease has or will become permanently established.

Spring Dwarf

Except for isolated fields, spring dwarf is known to occur in only two parts of the United States, namely, the Cape Cod and the Chesapeake Peninsulas. The disease has been found in individual fields near the following places: Merchantville, N. J., Taunton, Mass., Southington, Conn., Sawyer and Riverside, Mich., Wallace, N. C., Hamilton, Ga., and Custer, Wash.

Summer Dwarf

Summer dwarf is common in the strawberry-growing districts of the Southern States from Norfolk, Va., to Arkansas and Louisiana, and it has been found in southern Illinois. During recent years it has spread northward along the Atlantic coast and now occurs to a limited extent on the Chesapeake Peninsula as far at least as southern Delaware. Summer dwarf has been observed in fields near Los Angeles, Calif., on plants obtained from one of the Southern States where the disease is prevalent.

IMPORTANCE OF THE DISEASES

Spring Dwarf

Spring dwarf has been under observation on Cape Cod for the last 10 years, and the following comments are based on its behavior in that region. Information regarding other regions is still meager.

Severely affected plants usually set no fruit. If flower stalks are formed, they usually develop late and the fruit is small and misshapen. In one field near East Falmouth, Mass., the reduction in yield in 1938 was estimated at 60 to 70 percent, and the loss in another

field in this vicinity was about the same in 1939. During the last few years spring dwarf has been present in numerous plantings in the Falmouth region, but severe losses have been limited to a few growers who were unfortunate in choosing their sources of plants. How much this disease reduced the fruit production of this region as a whole for any given year can scarcely be estimated, but the figure would be small. Nevertheless, it is obvious that under favorable climatic conditions the disease can cause heavy losses if allowed to go unchecked.

Investigations thus far indicate that spring dwarf is favored by a mild, moderately cool, equable climate. It is not favored by a short spring season when hot summer temperatures come soon after the plants start growth, and probably it will not persist in regions with extremely cold winters. It should be emphasized, however, that there is very little information available regarding the potential seriousness of the disease under different climatic conditions and that the extent to which climate alone will limit its spread is not known.

Summer Dwarf

Estimates of losses due to summer dwarf vary widely. In this connection Brooks, Watson, and Mowry [3] write (pp. 500–501):

> The loss of plants, due to crimps, is 0–75 percent in individual fields and about 2 percent for the entire state [Florida]. * * * Crimped plants are worthless as fruit producers, because what fruit they do put on is late and of inferior quality. * * * The severity of the disease may result in the killing of the main bud, with the subsequent death of the plant, unless lateral buds chance to develop.

From actual field tests at Hammond, La., in 1930, on the comparative yield of healthy and dwarfed plants, Plakidas [4] reached the following conclusions:

> Healthy plants yielded 10.7 percent more per plant than the dwarfed ones. However, since the dwarf plants give a poorer stand than the healthy ones, if we take into consideration the number of dwarfed plants dying off, the yield per acre is about 32 percent better for the healthy ones. These figures will not apply to the field-run plants. The average percentage of dwarfed plants in a field is about 10 percent for the whole strawberry-growing section. So the decrease in yield due to dwarf for the average field is about 1 to 2 percent.

Although plants are killed only occasionally by this disease, they are weakened by it and rendered less able to withstand other adverse conditions. Field observations and tests by several investigators indicate that loss of plants through extremes of temperature, drought, and other climatic conditions is considerably higher among plants affected with summer dwarf than among those not so affected.

About all that can safely be said of the importance of summer dwarf is that it has for many years constituted a drain upon the strawberry industry of the South, but where careful avoidance of infected stock for planting is practiced, the disease has nowhere been of such decisive importance as to interfere seriously with berry production in any one district. Where strawberries are grown extensively for the sale of plants, however, the occurrence of either summer dwarf or spring dwarf may become a matter of very great importance.

[3] Brooks, A. N., Watson, J. R., and Mowry, H. strawberries in florida: culture, diseases, and insects. Fla. Agr. Expt. Sta. Bul. 204, [481]–523 pp., illus.

[4] Unpublished information supplied by A. G. Plakidas, Louisiana Agricultural Experiment Station.

CONTROL

For both spring dwarf and summer dwarf the most effective and practical control measure is to use uninfected plants for setting new fields. Where disease-free planting stock is used and certain precautions are taken to prevent subsequent contamination, either disease can be avoided. Possible sources of subsequent contamination are (*a*) carry-over in the soil from infected strawberries previously grown on the same land, (*b*) spread from nearby infected fields by runoff during heavy rains, and (*c*) spread from other infected fields by tillage implements and other media. The danger of carry-over in the soil is here discussed separately for each disease. The danger from runoff can be eliminated by adequate segregation of different plantings or, where this is not feasible, by the presence of dikes, ditches, or some other kind of water barrier. The danger of spreading either disease by farm tools or on the feet of horses, mules, or workmen is not thought to be very great. Avoid cultivating when the ground is wet and sticky after a rain and take reasonable precautions against transporting from one field to another any considerable quantity of soil or any strawberry plant that may be clinging to the cultivator.

In most instances it should not be unduly difficult to keep either disease at a point where it will have no appreciable effect on yield. As a matter of fact, in some parts of the South control methods already practiced, often unconsciously—roguing and procuring plants from districts where the disease is not common—have served to keep summer dwarf in check. The problem is more difficult for nurserymen who in many instances will be called upon to supply the necessary disease-free planting stock and where control measures should aim at eradication.

Spring Dwarf

The spring-dwarf nematode is not known to infect any plant other than strawberries; hence, there appears to be no danger that other crop plants or weeds will serve as reservoir hosts. Tests conducted near Falmouth, Mass., failed to provide any evidence that the nematode will survive in the soil from one year to the next. All available information suggests that with spring dwarf there is no serious soil-pollution hazard. If an infected field is plowed immediately after the picking season and set with disease-free plants the following spring, it is doubtful whether the disease will appear in the new planting through carry-over in the soil, certainly not enough to affect the yield of fruit appreciably. Where eradication of the disease is important, planting an intervening crop other than strawberries might be a wise precaution.

The most troublesome feature of spring dwarf is that the period of conspicuous symptoms does not begin until after much planting stock has been dug, and that by the time the plants in the newly set fields have become established and have made any considerable growth the period of symptoms has passed. When infected, some newly set plants, especially those set early, will develop recognizable though not usually conspicuous symptoms, but, unfortunately, not all will. Hence in a newly set field the disease may easily pass unnoticed during the first year even when present to a considerable extent. The following spring, plants may have been dug from these beds and set in

new fields before the symptoms appear and the grower is aware that the disease is present. It was precisely this situation that occasioned the heavy loss mentioned in a field near East Falmouth, Mass., in 1938 and in another in 1939. Obviously the grower who purchases plants is protected only by the integrity of the nurseryman who supplies them or by the inspection service of the State in which the plants were grown. The practice of digging plants in fall and placing them in cold storage for early spring shipment virtually precludes the possibility of effective inspection.

From the facts here set forth, it will be seen that roguing diseased plants is possible only to the extent of removing from newly set fields those that chance to develop symptoms. Attention to this, however, will reduce the prevalence of disease the following spring.

When selecting planting stock it should be remembered that even in spring, during the period of maximum symptoms, the nematodes are not necessarily confined to plants that are abnormal in appearance. Some apparently healthy plants may harbor small numbers of the parasites, and if set into new fields these infected plants and most of their daughter plants will eventually develop the disease. Plants cannot be selected from a field where the disease occurs with assurance that some infected ones will not be included. Of course, the more diseased plants there are and the more they are scattered over the field the greater the hazard. A grower can probably afford to select planting stock from fields where the disease is not too prevalent or widespread if he does this cautiously and during the period of maximum symptoms and if his purpose is merely control to a point where the yield will not be materially affected. When eradication is the goal, which should be the case in all fields grown primarily for planting stock, this procedure cannot be recommended.

The possibility of curing affected plants by hot-water treatment has never been tested. The spring-dwarf nematode has a comparatively low thermal death point, differing markedly in this respect from the summer-dwarf nematode. Treatment at a temperature between 115° and 117° F. for a period of about 15 minutes seems to offer promise. While such a treatment might be successful in special cases, it probably would not be practical on a commercial scale, as strawberry plants do not tolerate hot water very well and would need special handling after treatment.

Summer Dwarf

The summer-dwarf nematode has never been found infecting any plant other than the strawberry. Its ability to survive in the soil has never been tested experimentally, but this nematode will probably persist somewhat longer than the spring-dwarf nematode. Although the soil-pollution hazard is not regarded as a serious obstacle to control, there is evidence suggesting that the disease may carry over in the soil from one year to the next. After infected plants have been plowed under, the land should be planted to some crop other than strawberries for at least one year.

The extent of summer dwarf in a field can be substantially reduced by roguing. This may not be economical when carried out as a special operation, but it costs little to remove diseased plants when hoeing, and such routine is probably worth while. After all plants with recognizable symptoms have been removed, usually a few are left

that harbor the parasites but have not yet developed symptoms; hence, it is difficult to eradicate by roguing, no matter how scrupulously it is carried out. Rogued plants lying between the rows or near other plants will not spread the disease as long as they remain dry, but they should be removed by the end of the day or in any event before the next rain, for the parasites will remain alive in dry plants for a year or more.

The thermal death point of the summer-dwarf nematode is much higher than that of the spring-dwarf nematode; so high, in fact, as to preclude for all practical purposes any possibility of curing diseased plants by the hot-water treatment.

Both Diseases

Questions have been raised as to whether washing plants prior to packing for shipment will spread the diseases if some infected ones are inadvertently included and as to what extent the diseases will spread from plant to plant during shipment. What is known about the behavior of the parasites indicates that washing plants by submerging one lot after another in the same water involves a risk of spreading the diseases. This risk could be reduced, of course, by changing the water frequently. It has been demonstrated that part of the parasites will leave an infected plant and migrate into moist packing material, hence it would appear that the possibility of spread from plant to plant during shipment cannot be precluded.

Soaking infected plants in some solution prior to setting seems to offer little promise as a control measure. Nematodes are surprisingly resistant to many substances that are effective in killing other organisms, and no substance has been found that will reach and kill them without at the same time killing the tissues of the bud.

There is no evidence that the application of any known spray or dust has any control value.

Burning over the beds after the picking season, as occasionally practiced, is not likely to affect the prevalence of the diseases the following season enough to justify the injury inevitably done to the plants.

"Burning off" the foliage with experimental applications of calcium cyanamid failed to result in any appreciable reduction in the prevalence of spring dwarf the following season, regardless of whether the applications were made early in spring, after the picking season, or late in fall. It is unlikely that this procedure would be any more effective against summer dwarf.[5]

There is no reason for believing that the prevalence of the diseases will be affected either by using or omitting winter mulch regardless of kind or quantity.

[5] Unpublished information furnished by Wilber D. Courtney, Division of Nematology, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture; and Leo Campell, Western Washington Experiment Station.

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